Response to Crisis: The Ontario Metal Mining Industry 1975 - 1985

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Foreword

This working paper was sponsored by the Centre for Resource Studies as part of its program of making the results of academic research which is of relevance to mineral sector policy planners available to a broader and non-academic audience. This Working Paper Series is intended to provide information and analysis that will be of use in the decision-making process in the mineral sector, and to encourage further research and feedback from both academics and practitioners.

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Margot J. Wojciechowski
Executive Director

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We thank the Centre for its financial support and the Department of Economics, Queen's University, for providing office space. Our greatest debt is to Andrew Green who laboured through the original version to make sense out of a string of numbers and equations.

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1. Introduction

As we look back over the post-war period, the 1974 OPEC crisis apparently marks a major turning point in the economic development of western nations. In the period between 1945 and 1974 these countries enjoyed what has been called the "long boom". Prices during the period, although rising steadily, were increasing at manageable rates we can only envy today, less than 5 percent a year. Worker productivity soared, raising living standards remarkably. Average levels of unemployment were low, compared to the decade of the Great Depression of the 1930s and compared to the decade that followed. After 1974, however, things seemed to fall apart: prices soared, productivity growth slowed, and unemployment, especially among the young, rose to levels not seen for 40 years.

The Canadian economy followed this basic trend, probably doing better during the "boom" and falling further during the post-1974 period. The latter has often been referred to as a period of stagflation, i.e. inflation coupled with high unemployment and slow or zero productivity growth.

Within this global and national context, the mining industry prospered and then fell into its own period of desultory performance. In our earlier study of productivity growth in the Ontario metal mining industry, *Productivity and Labour Costs in the Ontario Metal Mining Industry,* Mineral Policy Background Paper No. 19, Ontario Ministry of Natural Resources, 1984, we showed that the productivity performance of the Ontario metal mining industry was, on average, poorer than that of any other industry over the downward cycle in the period that followed the rise in oil prices in 1974.

In the earlier study we offered a number of explanations for this relatively poorer performance. The reasons included

- loss of industry flexibility;

- loss of flexibility due in part to the growing share of white collar workers in the industry. Employment of this group responded more slowly to a downturn shift in demand than was the case for blue collar workers;

- industry facing a sharp rise in quasi-fixed indirect labour costs, many of these mandated by governments, but others entered into voluntarily as a result of negotiations between management and labour;

- finally, and not unexpectedly, given the lower demand for metals, a sharp decline in capital investment. This meant a slower adoption of new technology that normally accompanies such investment.

We have since updated the previous work, which covered the period from 1961 to 1979, to include the next decade and to ask the question: With the realization that world competitive conditions had changed dramatically after 1974, how well did the Ontario metal mining industry adjust to these new conditions? The answer, as will be shown, is quite well. However, the international demand for metals, at least by the end of our current study period, had not brought the industry as far back as it hoped and so some of the adjustments made between 1975 and 1985 had not reached the full level anticipated.

This report is an "every person's" summary of our update study, which was circulated as Ontario Ministry of Northern Development and Mines Policy Paper No. 25, a highly technical treatment of productivity and labour cost trends over the decade after 1974. It is our goal here to provide the general reader with an idea of how we reached our conclusions without the technical jargon.

The focus of this study is on productivity in the Ontario metal mining industry (excluding the refining sector). To develop this theme, productivity is analyzed for the individual factors of production: labour (L) in Chapter 2; capital (K) in Chapter 3; and energy and materials (E & M) in Chapter 4. Although each of these individual or partial productivities is of interest in itself, a great deal of interest in economics surrounds how their combined effect called total factor productivity (TFP), is related to output. We define TFP and explore its implications in Chapter 5. In Chapter 6 the focus shifts back to labour costs. Since this was a key concern in both

the earlier study and the update, we devote a full chapter in this summary to exploring the trends in labour costs, especially since the 1974 OPEC crisis. Finally, the results of our inquiry are brought together in Chapter 7.

2. The Use of Labour

Labour productivity is often seen as the single best indicator of industry performance. Indeed the mining industry measures efficiency by tons of ore hoisted per person-shift, which is just an indirect way to measure labour efficiency. Many economists also believe that labour productivity is not only the simplest measure to obtain but also the most insightful index of performance. In this chapter we first study the trend in output per worker in its simplest form (i.e. total output divided by total employment). Then we partition labour into two broad categories: white collar and blue collar workers. This split is somewhat arbitrary but, as we will see, how employers use these two broad groups adds to our understanding of the trends in total labour productivity.

Measuring Labour Productivity

There are two ways we may study the performance of labour productivity: as a *level*, and as a *rate of growth*. Both measures tell us something important about labour productivity. If we simply divide real output (Q) in an industry by total employment in the industry at a given point of time, say at 1975 and 1990, then we are estimating the level of output per worker (Q/L). The rate of growth of labour productivity is simply how fast labour productivity has changed between 1975 and 1990.

While the mathematics are simple, measurement of the two variables - output and labour - is not. In productivity analysis, real variables rather than nominal or current dollar values are used, since physical output is the key, not how prices have changed.

What is output? Clearly it is different not only for every firm but for every industry. Indeed firms often produce many different products. One measure of output is total sales, which is usually expressed in current dollar terms and must be deflated to remove the influence of price changes and get to the heart of the matter - the level and growth of *real* output. The deflation process is not easy, and we will leave that problem for another time.

In our work on the mining industry we have chosen to go directly to a volume measure of output: tons of ore hoisted. This index of output is not without its problems, but we see it as a reasonably good measure for what we are trying to do, and it is easily obtained in official statistical publications.

Labour or employment is easier to measure. We use labour measured in person-years as our denominator. Later in the chapter we partition labour into white collar (executive, administrative, professional sales staff, etc.) and blue collar (production and related) workers.

To examine some broad trends in labour productivity in the Ontario metal mining industry over roughly a quarter of a century, Table 1 was prepared. According to this measure of real output per employee, the average tonnage of ore raised in 1961 was approximately 1500 tons. A decade later this had increased to around 2,200 tons, and thereafter things deteriorated. By 1981 the average had declined to 1,640 tons and by the end of our period had regained some lost ground. The pattern of labour productivity, then, fits our understanding of general events in the years before and after the

Table 1

The Level of Labour Productivity in the Ontario Metal Mining Industry
Selected Years, 1961-84

Year	Output Per Worker (Q/L)[a]
1961	1,462
1965	1,719
1971	2,191
1975	2,018
1981	1,640
1984	1,925

Source: *Productivity and Labour Costs in the Ontario Metal Mining Industry*, Mineral Policy Background Paper No. 19 (MPBP 19), Ontario Ministry of Natural Resources, 1984, p. 129; *Productivity and Labour Costs in the Ontario Metal Mining Industry, 1975-1985: An Update* (MPBP No. 25), Ministry of Northern Development and Mines, 1987, p. 139.

[a] Q = thousands of tons of ore hoisted
L = employment measured in man years.

1974 OPEC crisis, with growth up to the early 1970s and decline showing up in 1975.

There are a number of ways to compute growth rates. The most direct is simply to estimate the percentage rate of change in average worker productivity between two dates. For example, worker productivity increased at a rate of 4.1 percent per year from 1961 to 1971 and declined at a rate of 2.8 percent per year over the next decade. This approach provides useful insight into the process of productivity change but it does obscure the factors driving these rates. The initial levels were rates; over time, the numerator and denominator change and clearly do so at different rates. It would be helpful to know whether the main cause of change was the rate of growth of output or changes in the size of the labour variable.

An alternative method of calculating growth rates, and one most often used in this type of analysis, is to compute the annual growth in output (ore hoisted, Q) and input (labour, L), and subtract the latter from the former. The difference represents the rate of growth of labour productivity. Hence one has three measures of growth: real output ($\hat{Q}$), labour ($\hat{L}$) and per-worker productivity ($\hat{Q} - \hat{L}$).[1]

Table 2 sets out the annual growth rates for these three variables for the period 1961 to 1984. The first point to note is the high volatility of the metal mining industry in all three dimensions: output, employment and per-worker productivity. Secondly, this industry has undergone a sharp drop in demand for its products since the early seventies. In three of the five sub-periods shown in Table 2, growth in real output was negative.[2] Output per worker, however, declined in only two of the five sub-periods, 1972-75 and 1977-81.

The time lag between output change and employment change is most interesting. In the early seventies, when international demand for Canadian metals started to decline, apparently the industry was reluctant to adjust the size of its employment to meet these new conditions. Most producers in mining and other fields saw the 1974 OPEC crisis as temporary. It was only some years later, with the full realization of how changed international conditions had become, that the industry began to adjust its labour input to match output trends more closely.[3]

The full employment adjustment did not really come until the 1980s. Employment levels began to decline and by the 1981-84 interval fell even faster than real output, reversing the declining trend in worker productivity. This change can be seen in Table 1 as well.

Homogeneous vs. Non-Homogeneous Labour Input

The above discussion assumes both homogeneous output and homogeneous labour input. Neither is realistic but let us concentrate here on the assumption of homogeneous (one-type) labour input.

Table 2

Average Annual[a] Growth Rates of Real Output[b], Labour and Output per Worker
Selected Periods, 1961-84

Time Period	Output ($\hat{Q}$) (1)	Labour ($\hat{L}$) (2)	Productivity ($\hat{Q}$-$\hat{L}$) (3)
1972-75	-1.4	1.4	-2.8
1975-78	1.7	0.9	0.8
1977-81	-5.8	-1.0	-4.8
1981-84	-0.8	-5.6	4.8

Source: MPBP 25, p. 39 and p. 44.

a Annual average within time periods

b For definition of real output see Table 1

c Column 3 = Column (1) minus Column (2).

We know that in practice the assumption of a homogeneous labour force is wrong. Employers hire people of all skills and with different levels of education and different years of experience. The productivity of individuals differs, depending at least partly on these skills. They are accordingly rewarded differently, with skilled workers on average earning 1.1 to 2.0 times what unskilled workers earn. The normal labour force is, therefore, non-homogeneous. In a simplified approach to examining the implications of this reality, we partition -

1 The ^ or "hats" designate annual compound rates of growth.

2 In Chapter II of MPBP 25, a detailed outline of price and quantity changes for gold, iron ore and other metals (copper, silver, nickel, etc.) over this period is given. The main conclusion is that, of the three groups, gold was the metal under strongest demand during this period. Metal prices tended to increase less than the general wholesale price index; i.e. a relative decline in the prices of these commodities marked this period.

3 The second OPEC shock of 1979 was instrumental in this realization. For a more complete discussion of this slow response, see MPBP 19, Chapter 3.

employment into two parts: white collar workers, largely administrative and professional people, and blue collar workers, mainly production-related employees. This division has both a theoretical rationale and a practical implication, arising out of the relative size and the growth rates of these two segments of labour force.

Table 3 sets out the number and the percentage distribution of blue and white collar workers, and reveals a dramatic shift in the structure of the labour force in this industry. The white collar workers increased from 13 percent of the total in 1961 to 26 percent by 1984, with two surges, in the late sixties and again in the early eighties. In absolute terms, the number of white collar workers increased, at least until the early eighties, while the number of blue collar workers declined (and indeed total employment) was falling.

Table 3

The Size and Percentage Distribution of White and Blue Collar Workers in the Ontario Metal Mining Industry
Selected Years, 1961-84

Year	Blue Collar (B)	White Collar (W)	Total Workers
Panel (A) Number of Employees			
1961	27,358	4,147	31,505
1965	23,850	4,240	28,090
1971	23,760	6,120	29,880
1975	22,093	6,532	28,625
1981	20,450	7,517	27,967
1984	17,543	6,109	23,652
Panel (B) Percentage Distribution			
1961	86.8	13.2	100.0
1965	84.9	15.1	100.0
1971	79.5	20.5	100.0
1975	77.2	22.8	100.0
1981	73.1	26.9	100.0
1984	74.2	25.8	100.0

Source: MPBP 19, p. 130; MPBP 25, p. 140.

What explanation can we offer for this realignment? First, it was not unique to metal mining.[4] What is interesting is that it occurred in this industry at a time when demand and real output were declining. Clearly, by keeping on white collar workers during a period of cyclical downturn, i.e. after 1974, employers were hoarding this labour in the hope that demand would increase. Simple human capital theory would predict such behaviour, because of the cost of searching for and training such skilled labour if business were to rebound. Of course, it did not rebound, and we shall see the consequences later in the chapter.

The other reason for the increasing share of white collar workers is the changing technology in the industry. More sophisticated equipment requires more highly trained workers, i.e. engineers, technicians, and their attendant clerical staff, and fewer unskilled workers. The growth of government regulations, new tax and subsidy schemes, more sophisticated international marketing also increased the need for white collar workers.

Although these new workers clearly added to the efficiency of the industry, the question arises as to the impact they had on overall worker productivity. To examine this point Table 4 was constructed. The main conclusion from this exercise is that the growth of white collar workers has dampened the growth in labour productivity and/or exacerbated its decline. In only two periods did it actually improve overall productivity growth - 1975-78 and 1981-84. Indeed, in this last period its contribution was substantial.

As outlined in more detail in MPBP 25, the fall in the number of white collar workers was long delayed. It did not come until the second oil price shock and the substantial decline in demand for many metals in 1981/82. In the original productivity study,[5] we called white collar workers a "quasi-fixed" factor of production. Like capital, this factor of production was difficult to reduce in the short run. However, our evidence shows that the term "quasi" was correct, since in the longer term white collar workers became variable factors of production and were laid off along with the blue collar workers. The delay was likely due, as noted previously, to the hope that business conditions would rebound; events of the early 1980s apparently dashed these hopes.

What, then, have we learned about the industry's response to crisis in terms of its handling of employment and so about labour productivity? The overall conclusion is that the adjustment lagged the decline in demand, especially in the case of white collar workers. This delay in adjustment lowered productivity as measured here in terms of real output per worker. The full adjustment did not come until the early 1980s, and with it came a rise in labour productivity.

[4] MPBP 19, p. 66.
[5] MPBP 19.

Table 4

Average Annual Rates of Growth of Real Output, White and Blue Collar Workers and Output per Worker for Blue and White Collar Workers, for the Ontario Metal Mining Industry
Selected Periods, 1961-84

Time Period	Output ($\hat{Q}$)	Blue Collar Workers ($\hat{L}_B$)	White Collar Workers ($\hat{L}_W$)	Productivity: Blue Collar ($\hat{Q} - \hat{L}_B$)	Productivity: White Collar ($\hat{Q} - \hat{L}_W$)
1961-72	2.5	-2.1	3.3	4.6	1.3
1972-75	-1.4	0.8	3.6	-2.2	-5.0
1975-78	1.7	1.0	0.4	0.7	1.3
1977-81	-5.8	-2.3	3.4	-3.5	-9.2
1981-84	-0.8	-4.7	-7.8	3.9	7.0

Source: MPBP 25, p. 39 and p. 44.

3. The Importance of Capital

Capital investment plays a crucial role in the competitiveness of an industry. New capital brings with it more and better "tools" for each worker. Economists term this improvement "embodied technical change", which means simply that new investment improves the efficiency of labour. If a firm fails to maintain its capital stock, its efficiency will decline relative to its competitors, and its market share will decline.

The mining industry is certainly no exception to this rule. In fact, since it is mainly an export industry, it is especially imperative that the best-practice technology be adopted as soon as it becomes available. Given the worldwide pace of technological change, this implies that this industry must be prepared to expend funds on capital investment on an ongoing basis. What, then, has been the investment pattern in the metal mining industry and how have these expenditures influenced productivity? Here we confine ourselves, as we did in the previous sector, to productivity changes solely in terms of this single factor - capital. We are implicitly assuming, at this stage, that the other factors, labour, materials, and energy, are performing at a similar pace. We will relax these restrictive assumptions in Chapter 5 when we examine total factor productivity, i.e. consider the impact of all factors simultaneously.

Defining Capital Stock

The concept of capital stock is not as clear-cut as the definition of labour. For labour, firms are asked simply to provide the Annual Census of Mines with the average number of employees for the previous twelve months.[6] Unfortunately, the Census does not ask firms for information on the size of their capital stock - machinery, buildings, etc. Rather, the questionnaire asks for "Fixed Asset Expenditures" undertaken over the previous year. This is a help for our purposes, but not as useful as capital stock information would be. In other words, we need information on total stock, but are provided instead with flow (investment) data.

This problem is not unique to researchers looking at productivity change in the Ontario metal mining industry. For example, work on US manufacturing productivity faces the same problem, and a number of imaginative solutions have been developed to obtain a proxy for capital stock estimates. The approach in this study is called "the perpetual inventory method" for deriving figures on real capital stock.[7] Essentially this method involves cumulating capital expenditures over a long period of time and then applying reasonable depreciation rates or "length of useful life" estimates to derive current dollar figures on capital stock. These figures are then deflated by an appropriate price index for construction costs. The result is a reasonably good estimate of the real capital stock.[8]

Table 5 presents levels of capital productivity using the perpetual inventory method for estimating capital stock. The figures shown indicate the amount of real output (ore hoisted) per unit of capital stock. It is analogous to the ratio for labour productivity shown in Table 1.

The results are slightly different from the labour productivity levels. From 1961 to 1971 average real output per worker rose, and the same trend line is evident for capital productivity (Table 5). Between 1971 and 1975 a divergence begins, as labour productivity falls slightly but capital productivity continues to rise. The 1980s show significant and interesting differences: capital productivity falls steadily, while labour productivity declines from 1975 to 1981 but then rises from 1981 to 1984.

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6 Energy, Mines and Resources, Ottawa, *Annual Census of Mines* (unpublished material).

7 For a full description of this method see Alan Green, *Productivity and Price: The Case of Gold Mining in Ontario*, 1984, CRS Working Paper No. 32, Appendix VIII.

8 Statistics Canada, *Stocks and Capital Flows*, various issues.

Table 5

The Level of Capital Productivity in the Ontario Metal Mining Industry
Selected Years, 1961-84

Year	Real Output Per Unit of Capital Stock (Q/K)[a]
1961	25,134
1965	30,407
1971	30,150
1975	31,421
1981	22,002
1984	18,067

Source: MPBP 19, p. 129; MPBP 25, p. 139.
[a] Q = real output
K = real capital stock

To get some perspective on these differing trends in labour and capital productivity, let us first consider the usual way of thinking about the relationship between output and capital. Normally we refer to the capital/output ratio, i.e. the reciprocal, or the ratio divided into 1, of the averages shown in Table 5. For the early 1980s, this capital/output ratio falls from 62.2 in 1981 to 55.3 in 1984 (see Table 6 for calculation). This is in sharp contrast with the earlier rates, which were 31.8 in 1975 and 32.9 in 1965. The capital used per ton of ore raised had jumped dramatically from its earlier level. The implication, confirmed in our results shown in Table 5, is that capital productivity was much lower in the 1980s than in previous decades. The industry in the 1980s had embarked on an ambitious campaign of new capital investment.

To get a different perspective on this relationship between output and capital, Table 6 was constructed. This table shows the growth of these two variables for selected periods from 1961 to 1984, and the difference between these two rates, which gives a measure of capital productivity (analogous to that in Table 2 for labour). We begin to see the cause for the decline in capital productivity. In the 1980s real output (demand) for metals declined sharply. In the face of this decline, the industry undertook what might be described as a massive capital-building strategy. Since output continued to decline, the difference (last column) is strongly negative. Although output fell, labour was being given more capital to work with and this was eventually reflected in rising labour productivity (Tables 1 and 2).

Table 6

Average Annual[a] Growth Rates of Real Output, Capital Stock and Output Per Unit of Capital Stock, Selected Periods, 1961-84

Time Period	Output ($\hat{Q}$)	Capital Stock ($\hat{K}$)	Productivity Per Unit of Capital Stock ($\hat{Q}$-$\hat{K}$)
1961-72	2.5	1.6	0.9
1972-75	-1.4	-5.7	4.3
1976-78	1.7	1.4	0.3
1977-81	-5.8	2.5	-8.3
1981-84	-0.8	6.3	-7.1

Source: MPBP 25, p. 39 and p. 44.
[a] Annual average within the time period.

Real Investment Trends

As we outlined earlier in this chapter, the reports of the Annual Census of Mines provide information on investment undertaken during the previous year. The information from these individual reports is then aggregated to yield provincial totals of investment in metal mining. Since we have computed real capital stock, it is possible to reverse the process and find real investment levels, i.e., the flow of real investment to the industry.[9] Table 7 shows these flows for the period 1975 to 1984.

The results are really quite spectacular. After an absolute decline in the level of real investment between 1978 and 1979 (a delayed response to the downturn in demand that began in 1974), the recovery was swift. Throughout the 1980s the average level of real investment was about $115 million per year, up sharply from the late 1970s where, if we exclude the one negative year, real investment averaged $25 million per year. At this stage we have no explanation for this dramatic reversal. One hypothesis is that the industry embarked on a counterattack against its foreign competitors using large-scale investment expenditures as its weapon. Clearly, more work needs to be done on this question.

[9] The difference between capital stock in year t and capital stock in year t-1 represents real investment flow.

Table 7

Real Investment Levels for the Ontario Metal Mining Industry, 1975-84

	Real Investment (millions of dollars)
1976-75	22.4
1977-76	29.5
1978-77	-22.1
1979-78	24.5
1980-79	90.7
1981-80	89.3
1982-81	54.7
1983-82	111.6
1984-83	229.1

Source: Figures derived from MPBP 25, p. 139.

Rate of Return to Capital

Another method of analyzing the productivity of capital is to estimate its gross rate of return (GRR). GRR is computed by subtracting gross payroll from value added and dividing this figure by the total assets, here taken as represented by the real capital stock. This measure is the gross company (industry) rate of return, before depreciation and corporate taxes. These are clearly crude estimates, and the actual levels are not of any particular interest. Our interest is really with the trend: is it rising or falling?

Table 8 set out the estimates of GRR for selected years from 1961 to 1984. Again, caution is necessary in interpreting the levels; it is the trends (slopes) that are being reviewed. The trends are intriguing. Basically the GRR was relatively flat during the decade of the 1960s. Sometime in the late 1970s it appeared to rise, although the reasons are not entirely clear unless we include in our explanation improved labour productivity. These high gross rates in the late 1970s may have been part of the reason for the massive investments of the early 1980s. These latter investments, in the absence of rebounding demand, caused a fall in the trend of GRR which began to recover only by 1984. The element that seems most consistent with the earlier evidence on investment levels is the declining gross rate of return that occurred simultaneously with the investment of the early years of the 1980s and appears also in Tables 5 and 6 as a fall in capital productivity.

Table 8

Gross Rate of Return (GRR) to Capital in the Ontario Metal Mining Industry
Selected Years, 1961-84

Year	Gross Rate of Return (GRR)[a]
1961	18.2
1965	21.6
1971	16.7
1975	45.3
1981	57.0
1982	47.4
1983	48.4
1984	54.9

Sources: MPBP 19, p. 63; MPBP 25, p. 118.

[a] Gross Rate of Return (GRR) = Value added minus gross payroll divided by the real capital stock for the industry.

Service Price of Capital

Investment is not a costless exercise. For most new capital goods the company must go to the market and pay interest on the borrowed funds. Even if the funds are raised from retained earnings, the firm must calculate an implicit cost of this capital. What, then, were the trends in the cost of servicing the investment boom in the 1980s?

The service price of capital (defined as the opportunity cost of borrowed funds, i.e. the interest rate on long-term bonds) is the counterpart to the gross wage bill paid by a company to cover the total cost of the workers it employs. In essence, then, the service price of capital is the cost to a firm of using a real dollar's worth of capital in a given year. It depends on depreciation and taxation practices, the opportunity cost of capital (i.e. the market cost of borrowing funds), the rate of depreciation, and the price of new equipment.[10]

Table 9 sets out the results of this complex estimating procedure. The first point to note is that the cost jumped by 72 percent between the late 1970s and early 1980s. Two factors account for this increase.

[10] For a complete description of how the service cost of capital is computed for the Ontario metal mining industry, see MPBP 25, pp. 65-66.

Table 9

Index of the Service Price of Capital for the Ontario Metal Mining Industry
Annually, 1978-85

Year	Service Price[a]
1978	.278
1979	.324
1980	.425
1981	.555
1982	.597
1983	.529
1984	.568
1985	.507

Source: MPBP 25, p. 67.

[a] Service price of capital is defined above on p. 9. A full explanation of the calculation procedures can be found in Alan Green, *Productivity and Price: The Case of Gold Mining in Ontario*, CRS Working Paper No. 32, p. 30. This measure is indexed to the price of new capital equipment.

First, corporate bond rates increased from an average of 11 percent in the late seventies to between 13 and 15 percent in the early 1980s, although they eased back slightly by 1984. The second factor is the sharp rise in the price of new capital goods; between 1980 and 1985 the price of such goods rose from an index of 230.6 to 291.3, an increase of 26 percent in five years. In other words, capital investments during the boom of the 1980s were undertaken in a climate of steeply rising costs. We can assess the rationale for this undertaking only in the light of the trend in labour costs (which we examine in Chapters 5 and 6).

Summary

The response of the industry to events following the 1974 OPEC round of price increases in terms of investment decisions was similar to its employment strategy, in the sense that it was invoked with a lag, although with a shorter lag in the case of capital. Capital investment increased sharply in the early 1980s, while massive reductions in employment came several years later.

The timing of the two trends may not be unrelated. During large-scale investment, workers are needed to put the new capital in place. This fact might also explain the continued rise in white collar workers, since the new capital was clearly more sophisticated than the equipment it was replacing. However, the main goal of such investment is to replace labour. Once the new capital stock is in place, the substitution of capital for labour can take place. This may in part account for the sharp fall in employment that occurred after 1981.

This said, it was clearly the basic strategy of the industry to regain market share by means of large-scale investment in new equipment. The pay-off would have to await a general recovery in demand and the restoration of full-capacity production.

4. Energy and Material Inputs

In many studies of productivity, energy and material inputs are not explicitly included. Often this information is simply not available[11] and so gross sales or net output may be used to calculate it. Net output is simply the difference between gross sales and the purchase of materials and energy. This implies a separability of these inputs from capital and labour, a fairly restrictive assumption in most cases, and an entirely unacceptable one in a study of the mining industry, since material and energy inputs play a vital role in determining the level and growth in output.

Defining Materials, Supplies and Energy

The provincial figures for materials, supplies or energy used in this study originate, as do most of the data used here, from the reports of the *Annual Census of Mines*. The questionnaire asks for information on:

- consumption of purchased fuel and electricity, which includes expenditures on gasoline, natural gas, electricity purchased, etc.;

- process, operating, maintenance and repair supplies, which includes explosives, steel, repair and replacement parts, etc., i.e. a mixed-category input which should be treated accordingly.

We have therefore separated energy from materials for analytical purposes.

Table 10 shows that the long-term trend has been downward. This is not easy to explain. The decade of the 1960s was one of expansion of demand growth and output while that of the 1970s, especially after 1974, was marked by contraction, although real investment continued positive but at a lower level. The 1980s, as noted, was a decade of investment boom.

Table 10

Levels of Output[a] per Unit of Materials and Energy Inputs
Selected Years, 1961-84

Year	Materials[b]	Energy[c]
1961	539	3.84
1965	498	3.82
1971	362	2.13
1975	422	1.72
1981	308	1.98
1984	383	1.90

Sources: MPBP 19; MPBP 25, p. 139.
[a] Measured in tons of ore hoisted
[b] Measured in constant dollars
[c] Measured in BTU's

The use of materials clearly expands more rapidly than real output during periods of expansion and new investment. This might well account for the sharp decline in output per unit of material input between 1961 and 1971, which levels off somewhat in the first half of the 1970s. The sharp fall after 1977 is hard to explain, as is the recovery thereafter. These trends are important for total productivity, as we will see in the next chapter, since the cost of materials represents close to 30 percent of total sales.

Energy efficiency also experienced a sharp downward trend in level between 1961 and 1975, and some recovery from 1975 to 1984. Table 10 shows that the average level of output per unit of energy input in 1975 was less than half what it had been in 1961.

[11] Zvi Griliches, "Returns to Research and Development. Expenditures in the Private Sector" in Kendrick and Vaccara, *New Developments in Productivity Measurement and Analysis*, NBER Studies in Income and Wealth, Volume 44 (Chicago 1980), Chapter 8.

Before we get into explanations, especially for energy productivity, we should examine the growth trends for real output and for these two inputs shown in Table 11. Let us begin with materials. Column 2 shows the vague outline of a cyclical growth rate, with a decline in real material usage in the decade following the 1974 OPEC crisis, which was also a period of declining demand (output). As in the case of labour, the major cutback in real materials inputs came in the period 1981-84. By then it was sufficient to turn the desultory productivity performance for materials in the previous decade into a quite spectacular increase, 6.3 percent per year over the period 1981-84. Whether this signified real conservation in the use of material in the face of tough times, or a relative drop in prices for materials, is not known. Since the available figures give only totals for materials, we are unable to examine the structure of the change. This must await a micro or firm-level study. For example, did the decline come in repairs (which is like investment) or in explosives, lumber, steel, etc.? Materials productivity deserves our close attention, given its importance in this industry.

The case for energy growth is even more complex. As one can see from Table 11, the growth rate in real energy consumed by the industry plummeted after 1972. This, of course, roughly corresponds to the sharp rise in energy prices associated with the 1974 OPEC crisis. One might expect such a change on the basis of the increase in energy price alone, although this is not the sole reason. The level of energy use is also a function of the technology in place. Although energy prices can change rapidly, the conversion to energy-efficient technology cannot be made quickly. Hence what we may well be observing, at least in part, is a drop in demand for energy related to reduced operating levels and commensurate with the decline in demand for and output of metals, as shown in column 1 of Table 11. The clearest indication of this positive association between annual changes in real output and energy use is the period 1977-81, when real output declined at an annual rate of 5.8 percent while energy use declined at 7.9 percent per year. Correlation does not necessarily imply causation, and so we should draw such conclusions carefully; nevertheless, there appears to be some validity in suggesting that the trends in output and energy use are related.

Another possible reason for the decline in the growth of energy use is improved conservation practices. Higher prices for electricity induce all of us to turn out lights and turn back the heat, and businesses are certainly no exception to this behavioural instinct. It might well be that part of what we are observing are attempts by the industry to cut energy consumption in the face of a sustained rise in the price for this input - a sustained rise that went hand-in-hand with a fall in output prices, thus putting a potential squeeze on profits. However, one should put a *caveat* on this point as well. In the next chapter, which sets out the various cost shares for wages, capital, materials and energy, we find that energy's cost share is less than 5 percent. Since energy is such a small share, one must at least question how much effort went into conservation.

How far was energy consumption cut, relative to the fall in real output? The productivity trends shown in the last column do not give a lot of encouragement. In three of the five periods, productivity growth was negative, and in only one - 1977 to 1981 - was it above 2.0 percent. At this level of analysis one cannot see great strides in reduction of energy use to conform with the drop in demand. However, it is worth repeating that sharp

Table 11

Average Annual Rates of Growth
Selected Periods, 1961-84 (percent)

	Real Output	Real Materials	Energy	Output per Unit of Material Input	Output per Unit of Energy Input
1961-72	2.5	4.7	9.0	-2.2	-6.5
1972-75	-1.4	-1.3	2.6	-0.1	-4.0
1975-78	1.7	1.5	0.4	0.2	1.3
1977-81	-5.8	-1.2	-7.9	-4.6	2.1
1981-84	-0.8	-7.1	0.6	6.3	-1.4

Source: MPBP 25, p. 39 and p. 44.

cuts in energy use are probably precluded by the nature of the existing industry technology.

Energy and Capital - Complements or Substitutes?

There is a great debate over whether energy use and capital are complements (i.e. whether demand or use for each rises and falls in unison with price changes), like sugar and coffee, or whether they are substitutes, like potatoes and meat. This is an important question, for it has much to say about the industry's performance.

For example, if capital and energy are complements, in the economic sense, what happens when the price of energy rises and less of it is used? Complementarity would imply that less capital would be used, and per-worker productivity would fall. If they are substitutes and the price of energy rises relative to the price of capital, then less energy input translates into more capital usage and hence greater labour productivity.

Although this is not the place to explore this issue in depth, one might be interested in how energy usage did change, relative to changes in the growth of capital stock. Table 12 sets out this relationship: the growth in capital stock is simply subtracted from the growth in energy usage (analogous to subtracting the growth of employment from the growth in real output to get output per worker), to give energy used per unit of capital stock.

Table 12

Average Annual Growth[a] in Energy Use Relative to the Growth of Real Capital Stock
Selected Periods, 1961-84

Time Period	Energy ($\hat{E}$) (1)	Capital Stock ($\hat{K}$) (2)	Energy Minus Capital Stock ($\hat{E}$-$\hat{K}$) (3)
1961-72	9.0	1.6	7.4
1972-75	2.6	-5.7	8.3
1975-78	0.4	1.4	-1.0
1977-81	-7.9	2.5	-10.5
1981-84	0.6	6.3	-5.7

Source: MPBP 25, p. 39.

[a] Growth = annual average rates of growth for the time periods shown.

It is difficult to discern clearly whether these two factor inputs are substitutes or complements. In the 1960s they did grow together (compare column 1 and column 2 of Table 12 for the period 1961-72). In fact, we get positive signs for the two inputs in three of the five periods, although as we can see from column 3 that the growth rates differed. However, it is not clear what we should read into the other two periods: 1972-75, which includes the rise in energy prices associated with the OPEC crisis; and 1977-78, when the second rise in use occurred. There is only a slight hint of some substitution possibilities.

Summary

The response of the industry to the oil crisis of 1974 in terms of materials and energy usage is unclear. Productivity declined in both, and it was not until very late in our period of investigation that the industry was able to make significant cuts in these two inputs relative to the decline in real output (demand). Are we, then, observing again a lag in the realization that the world was and would continue to be different after 1974 and/or are we observing a change in technology that finally allowed savings on both these fronts? At this level of industry aggregation we cannot reach definitive conclusions. However, the evidence does show that, after some delay, the industry's response was positive in terms of enhanced productivity for materials and energy usage.

5. Total Factor Productivity

In the previous three chapters we analyzed productivity change in the Ontario metal mining industry as a series of quite separate trends, i.e. the trends in the average real output per unit of labour, capital, materials and energy. This is a straightforward empirical exercise. Although it is useful in itself, this approach does not capture the impact of all the factors working together to influence the level and growth of real output.

Economics is, among other things, the study of maximizing returns, subject to constraints on real resources. This concept of maximization is absent from our discussion as long as we treat the factors separately and do not put them together into a more logical framework which permits us to estimate and analyze total factor productivity. It is to this measure of productivity that we turn in this chapter.

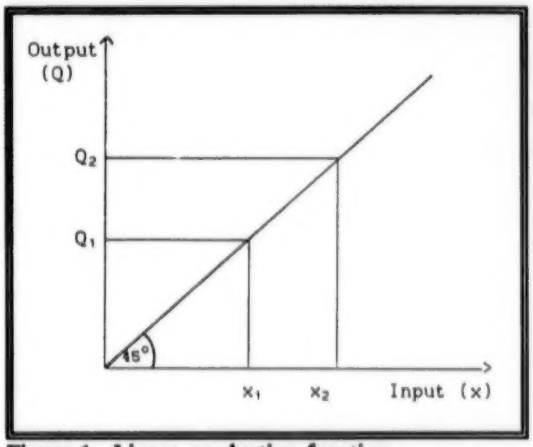

Figure 1. Linear production function

The Definition of Total Factor Productivity (TFP)

The analysis of productivity change up to now has been an empirical exercise. It has not attempted to use the concept of "maximization subject to constraint" that lies at the heart of all economic analysis. Our interest here is with maximizing output subject to constraints on real inputs: labour, capital, materials, etc., and we can undertake such an exercise only within the framework of some model. The model used in this type of analysis is a production function which systematically relates the inputs to measured output.

The production function can be described, although imperfectly, with words. The object is to combine all the inputs in some form that represents how we see output changing as inputs change. For example, the production function could be simply a linear relationship, such as that shown in Figure 1.

We could represent this production process with a simple linear equation which shows that, as we double inputs, real output doubles. Of course, there are more complex forms: for example, it might be the case that, as inputs increase, initially we more than double output but eventually, as more inputs are added we observe less-than-proportional increases in output?

There are three possible relationships between inputs and outputs: constant returns to scale, as outlined in Figure 1; increasing returns to scale; and decreasing returns to scale. The latter two cover all cases where outputs and inputs do not change proportionately. There are many variations of these three relationships, some very complex mathematically. We have chosen the first, and simplest: the Cobb-Douglas Production function,[12] which assumes constant returns to scale. The concept of constant returns to scale, although restrictive, avoids the complexities inherent in models that allow for changing returns to scale. Without trying to be confusing, it should be noted that it is possible, with enough data, to tell whether a particular production relationship is or is not one of constant returns to scale.

[12] For a mathematical representation of the Cobb-Douglas Function see Appendix A.

We must have some method of combining the various inputs, of "adding them up". As you will recall, all inputs and outputs are measured in real terms; i.e. the price effects have been removed. Since we cannot simply add the number of employees to the dollar value of capital stock, we need some form of weights. The weights used are the factor shares, which represent, in the mathematical form of the function, the marginal products of each of the factors (economists are always dealing at the margin).

This is where the concept of maximization enters the discussion. We want to combine all the factors in such a way that the marginal product of each input is maximized. The marginal product is simply the amount of additional output we get by increasing a given input by one unit, holding all the other inputs fixed. Adding units of one input while the rest are held constant will ultimately lead to diminishing returns. For example, how much labour can be put on an acre of land before the workers start bumping into one another, reducing productivity and slowing output growth?

Although we cannot measure marginal productivity, it can be shown that factor shares are a good proxy. Factor shares are measured by dividing the total cost of a given factor used to produce a certain value of sales by the values of sales. For example, we can get the factor share of labour by dividing the total labour cost or wage bill for a year by the total sales for that year. We do a similar exercise for each factor input and then average these individual estimates over the number of years for which we have data. We then use these average share levels to weight the various inputs.

In a Cobb-Douglas production function, the mathematical form (since the function is one representing constant returns to scale) states that the shares add to one. We express all inputs in log form, i.e. in terms of the change in inputs and outputs.

Measuring Total Factor Productivity

What is total factor productivity (TFP)? In fact, it is not the total of all the factors' productivities; rather it is a residual. In empirical terms, it is simply the difference between the growth of output and the weighted growth of all the inputs, where the weights are the factor shares discussed above. This difference, or residual, captures all those things influencing output that are *not* captured in the contribution of the *measured* inputs. It is an amalgam of factors such as technological change, economies of scale, organizational improvements, and improvement in labour skills, and is generally viewed as an index of technological change. It might not surprise many readers that economists also call this index a measure of our ignorance.

As a residual, TFP "absorbs" any errors and mismeasurement that emerge in the estimation of the measured inputs, and so must be treated cautiously. However, we are principally interested in the trends in this index, where the errors should tend to cancel out. Table 13 sets out our estimate of total factor productivity for the Ontario metal mining industry annually from 1975 to 1984. The index was derived from the inputs analyzed in the previous three chapters.[13]

Table 13

Index of Total Factor Productivity for the Ontario Metal Mining Industry
Annually, 1975-84 (1975 = 100)

Year	TFP Index
1975	1.00
1976	1.03
1977	0.97
1978	1.01
1979	0.88
1980	0.80
1981	0.74
1982	0.62
1983	0.67
1984	0.76

Source: See MPBP 25, Table IV-6, p. 52. Figures here differ in level from those shown on this page due to the use of different weights.

The pattern of long-term changes in total factor productivity is really quite intriguing, especially in light of our discussion in the previous chapters. First, the index remained relatively unchanged during the last half of the 1970s, despite all the disruptions caused by the 1974 OPEC crisis. Second, the decline really began with the second OPEC shock in 1979, and continued until 1983. Third, the turn-around started in 1982, with an annual rate of increase of 10.7 percent until the end of our period. We need to examine the underlying series to get some sense of why this residual is moving in this cyclical fashion.

[13] The weights for labour (L), capital (K), materials (M) and energy (E) used were
L = .22, K = .38, M = .35 and E = .04.

Recall that total factor productivity is a measure of efficiency gain or loss and is the residual remaining after accounting for the growth in the measured inputs: in this study, capital, labour, materials, and energy. The only way to understand these changes in TPF is to present the trends in output and input growth, as shown in Table 14.[14] Although world events began to change in 1974, metal mining demand and output continued to rise until 1978. It fell sharply in 1979 and again when it bottomed out in 1982.

Our interest here is in the response of inputs to this decline in output, since it is the interaction between these two that spells out trends in partial and total factor productivity. Labour input is an interesting case in point; it fell at about the same rate as output until 1979, but in the 1980s labour input rose as real output continued to fall. Not until 1983/84 did it fall back to the 1979 level. Capital input, on the other hand, rose over the whole period, indeed quite spectacularly after 1980.

The energy trend offers a very different pattern, falling in 1978, four years after the first OPEC crisis, and continuing this decline virtually for the balance of our study period. It more or less paralleled the fall in real output and it is difficult to see any major conservation, at least relative to output. In terms of capital, there was a clear substitution towards this factor and away from energy and labour.

What does all this mean? First, let us explore the relationship between the index of TFP and the first measure of productivity we analyzed - output per worker. We suggested earlier that some scholars felt that output per worker is a sufficient index to trace out general trends in productivity, and in fact Figure 2 shows that indeed the two track roughly the same pattern. In the early 1980s, per-worker productivity falls faster than TFP, indicating that efficiency was greater in capital, materials and energy than in labour. Since 1982, labour productivity has risen faster than TFP, indicating that labour was being combined more efficiently with other inputs, capital in particular.

Table 14

Ontario Metal Mining Industry Indices of Real Output; Capital Stock, Labour, Materials and Energy Inputs; and Total Factor Productivity
1975-84 (1975 = 100)

Year	Total Factor Productivity $\hat{A}$[a] (1)	Real Output $\hat{Q}$ (2)	Real Capital Stock $\hat{K}$ (3)	Labour in Man Years $\hat{L}$ (4)	Materials Input $\hat{M}$ (5)	Energy Input $\hat{E}$ (6)	Total Wtd Inputs $\hat{I}$[b] (7)
1975	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1976	1.03	1.06	1.02	1.01	1.07	1.11	1.03
1977	0.97	1.03	1.03	1.02	1.14	1.01	1.06
1978	1.01	0.95	1.02	0.81	0.98	0.91	0.94
1979	0.88	0.80	1.03	0.80	0.91	0.67	0.91
1980	0.80	0.81	1.08	0.95	1.04	0.70	1.01
1981	0.74	0.79	1.13	0.98	1.08	0.69	1.07
1982	0.62	0.57	1.16	0.90	0.73	0.61	0.92
1983	0.67	0.63	1.22	0.80	0.77	0.65	0.94
1984	0.76	0.78	1.35	0.81	0.85	0.70	1.02

Source: MPBP 25, p. 139

[a] Total factor productivity is derived by dividing column (2) by column (7).

[b] The weights used were K = .3786, L = .2249, M = .3505 and E = .0407.

[14] Trends in these same variables for the period 1961 to 1975 are shown in Appendix B. We will refer to them only briefly in the following discussion. However, for the reader with a longer-term interest in this industry's development, these two tables provide a quarter-century of continuous evidence.

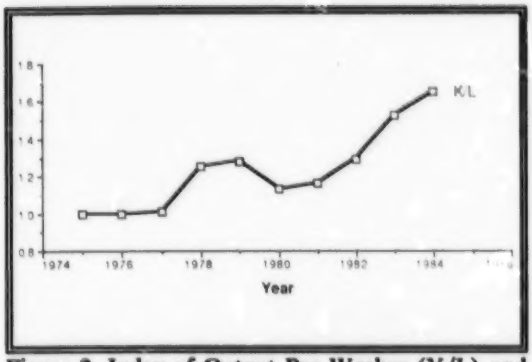

Figure 2. Index of Output Per Worker (Y/L) and Total Factor Productivity (A/A)

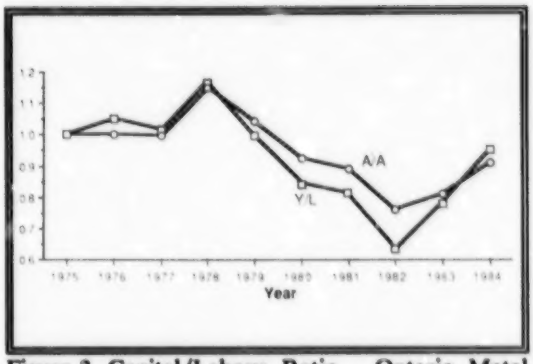

Figure 3. Capital/Labour Ratio - Ontario Metal Mining Industry

The trends in the input shares of capital and labour shown in Table 14 and Appendix B indicate that, from the early 1970s, capital input has been growing faster than labour input, and that this pattern accelerated significantly in the 1980s. By the mid-1980s the capital index was 1.35, while the labour index stood at 0.81. We see this substitution of capital for labour clearly in Figure 3, where the ratio begins to rise after 1981, returning to the 1979 level by roughly 1983, and thereafter soaring above previous levels.

Cost of Capital Relative to the Cost of Labour

What is the economic rationale for such a massive shift towards more capital per unit of labour input? On one level, the answer is quite simple: producers attempt to minimize costs of production and, since the cost of labour has risen over time, clearly there is an incentive to replace labour with a cheaper input. Capital has historically been that cheaper alternative. More and newer capital also brings new production techniques and increases the productivity of labour. The joint effect, more capital, and its counterpart, more efficient labour, has been the trend in modern industries since the earliest stages of industrialization.[15]

Identifying the effect of technology and technology change is not easy. We are not dealing, in the mining industry, with the production of a uniform product, using a standard manufacturing process. Mining technology may be specific to a given orebody, and related to factors such as conformation, size, location and ore characteristics. This heterogeneity of technology in mining means that the substitution of capital for labour does not occur in a uniform manner throughout the industry.

We cannot resolve this problem at this level of data aggregation. However, we can take a first step, and explore the relative prices of capital and labour. An index of the service price of capital was divided by an index of the average cost of labour. The *trend* in this ratio is the relevant feature, not the *level* of this index.

We have set the base year at 1981 as it is roughly in the middle of the period covered. The trend in the relative cost of capital (P_K) to the direct cost of labour (P_L)[16] is shown in Table 15. This index was calculated by dividing an index (1981 = 100) of the service price of capital by an index of average compensation of labour.

The trend in the price of capital relative to that of labour is quite interesting. Over the period 1978-84, taken as a whole, the price of capital, measured as its service price, has risen relative to the price of labour. The trend, however, is not consistent: after an initial steep rise in the relative price of capital from 0.618 in 1978 to 1.06 in 1982, the trend reversed and the price of labour has since risen relative to the price of capital. Since, overall, the price of capital has risen relative to the price of labour, economic theory predicts that firms would

[15] We will have to leave the discussion of which firms tend to innovate more than others - is it, for example, related to size of the firm, does it improve efficiency more per unit of increased output for small vs. larger firms? There is a whole range of questions that the aggregate or industry level data used here cannot address. At this stage we can only observe broad changes. We need micro or firm-level data to analyze how these factors enter the decision-making process.

[16] Direct cost of labour is referred to throughout as a price of labour, to distinguish it from the cost (direct plus indirect) of labour.

Table 15

Index of the Price of Capital Relative to the Price of Labour, for Ontario Metal Mining 1978-84 (1981 = 100)

Year	P_K/P_L [a]
1978	0.618
1979	0.647
1980	0.824
1981	1.000
1982	1.056
1983	0.883
1984	0.916

Source: MPBP 25.

[a] P_K = index of the service price of capital (see p. 9).
P_L = index of the wage cost of labour (see Table 16).

substitute labour - the relatively cheaper factor - for capital over time. This has not happened: instead, the capital/labour ratio has risen over the study period. In 1975 it was 100.0, and in 1984 it had climbed to 106.5.

This upward trend in the relative price of capital after 1978 continues the path set between 1965-67 and 1971-79[17], and we suspect that this upward trend in the P_K/P_L ratio has continued for almost twenty years. This upward trend would be modified slightly if indirect labour costs were included in the price of labour.[18]

This still leaves open the whole question of the degree of substitutability between capital and labour. In our original study,[19] we reported on findings that suggested a low degree of substitutability. However, as noted previously, this question cannot be answered at the level of aggregation used in this study. One might also add that, until very recently, virtually all studies of industry productivity performance have been carried out at this or even a higher level of aggregation. However, we believe it will be necessary to account for specific production techniques in constructing useful economic indices for productivity measurement.

Long-Term Patterns

The long-run patterns of responses of the industry to changes in the relative costs of inputs, and changes in output, are quite revealing. From linking Table 14 and Appendix B, an interesting story emerges. During the 1960s and at least through until the late 1970s, all four indices - output, capital, labour and total factor productivity (TFP) - increased more or less in parallel; the TFP index grew slightly, at an annual compound rate of 0.08 percent. The story in the decade covered in this review, from 1975 to 1984, is quite different: capital grew, relative to labour (Table 14) and TFP actually declined, at an annual rate of 2.9 percent per year.

Reviewing the Evidence

What does all this mean in terms of how the Ontario metal mining industry responded to external events? First, it did respond by adjusting its inputs to help it meet changing demand and foreign competition. The basic approach has been to substitute capital (technology) for labour. This has been especially pronounced since the early 1980s. It also appears that the industry has cut its energy usage, either through adopting more energy-efficient technology (a step that requires a long lead-time) or through incremental methods of conservation in the use of energy with existing technology.

The overall results as measured in terms of total factor productivity were not spectacular up to the end of the period studied, 1984. Nevertheless, labour productivity did improve, at least in the early 1980s. Apparently, to realize the benefits of its increased capital inputs, the industry had to wait until demand increased after 1984; i.e. had to await the return of higher levels of capital utilization. The subsequent results, one suspects, will prove to be quite positive. The short-run costs of heavy investment positioned the industry to meet the post-1984 resurgence of metal demand efficiently and effectively.

[17] See MPBP 19, p. 20.
[18] Inclusion of indirect labour costs would dampen the increase in the P_K/P_L ratio.
[19] MPBP 19.

6. The Cost of Labour

Firms can attempt either to maximize output per unit of input or to minimize costs per unit of input. We have dealt exclusively in a production framework that assumes the concept of maximization. This section switches to the cost side of the equation. We do not attempt a full analysis of developments in the Ontario metal mining industry from this alternative perspective. Our concern is much more limited: we focus almost exclusively on labour costs.

This focus on labour costs is not meant to suggest that this factor alone explains all that has happened in the industry. Far from it. As we saw, the share of material costs share is larger than that of labour costs. Yet recent developments in direct (i.e. wages or take-home pay) and indirect (i.e. fringe benefits, holidays, etc.) labour costs have changed the picture dramatically since the early 1960s. The sharp rise in indirect labour costs raises the whole question about the difference between the price of labour (direct) and the cost of labour (direct plus indirect). We address the trends and implications of these developments in this chapter.

Cost of Production

The index of costs depends on two factors: input prices and technical efficiency. We have attempted to capture this dual impact in the calculations shown in Table 16. This table sets out the "cost" of two factors only - capital and labour. An index of the service price of capital is shown in column 1.[20] It covers interest and depreciation costs and incorporates new machinery prices, and represents the price of capital goods. The "price of labour" index is obtained by dividing total employee compensation (direct labour costs) by the average number of workers employed in the given year.

The equation[21] used to estimate the weighted total cost index (column 3 of Table 16) is very similar in construction to the production function referred to in the previous section. The weights used for capital (C_K) were .380 and for labour (C_L) were .620. We are assuming that productivity of the excluded factors - materials and energy - is the same as that of the measured factors - capital and labour.

As we noted above, cost depends on both the price of the factors purchased and the efficiency with which these factors are used. The cost index is adjusted for efficiency by dividing the index of total factor productivity (column 4) into the weighted index for capital and labour (column 3). We begin in 1978, when the necessary price indices became available.

As one can see by comparing columns (1) and (2), the rate of increase was almost identical for the two factors: in 1984 the capital index reached 1.82, while labour was 1.83. The paths over the interval 1978-84 were, however, very different. The price of capital more than doubled between 1978 and 1982, then fell from 1982 to 1984, while the price of labour grew steadily over the whole period.

There are a number of ways to interpret these indices of capital, labour and efficiency. One way to measure the growth of real costs is simply to take the negative of total factor productivity, which decreased by 4.2 percent annually. This implies that, over the period, real costs were growing at about 4.2 percent per year. Another method is to divide the weighted index of prices of capital and labour (column 3) by the change in total factor productivity (column 4). The former rose at an average annual rate of 10.4 percent. However, when this weighted price index is divided by the TFP index (column 4), the ratio of prices and efficiency increases at an average annual compound rate of 15.9 percent.

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[20] See MPBP 25, p. 65 for the formula used to calculate this index.

[21] The formula can be found in R.C. Allen, "International Competition in Iron and Steel, 1850-1913", *Journal of Economic History*, Vol. XXXIX, No. 4 (December 1979), p. 930.

Table 16

Indices of the Service Price of Capital, the Average Price of Labour, Weighted Cost Inputs, TFP and the Ratio of Total Costs and TFP (1978 = 100)

	Service Price of Capital (1)	Average Compensation Per Worker (2)	Weighted[a] Total of Capital Cost and Labour Cost (3)	TFP[b] (4)	Index of Costs[c] Adjusted for Efficiency Changes (5)
1978	1.99	1.00	1.00	1.00	1.00
1979	1.17	1.13	1.14	0.87	1.31
1980	1.52	1.22	1.34	0.79	1.70
1981	2.00	1.37	1.61	0.73	2.20
1982	2.14	1.44	1.70	0.61	2.78
1983	1.90	1.60	1.71	0.66	2.59
1984	1.82	1.83	1.82	0.75	2.43

Source: MPBP 25, pp. 67 and 71.

[a] Weights used are C_K (capital cost) = .380 and C_L (labour cost) = .620.
[b] See Table 13.
[c] Column (3) divided by column (4).

The implication is quite clear: efficiency gains were not offsetting increases in the prices of labour and capital, and costs in the industry were rising fairly sharply. As in the case of capital, the path of the efficiency-adjusted index was not monotonic, but rose steadily until 1982, along with the price of capital, and then fell to 2.43 in 1984. Both the price and size of the capital stock were important determinants of cost. Like capital price, the rising size ofthe capital stock affected the TFP, in the absence of a recovery in demand for metals. However, generalizations about the impact of real investment and the resulting growth of real capital stock on efficiency and costs are dangerous at this level of aggregation, and better left to analysis with more firm-specific data. For the balance of this chapter we focus on the cost of labour.

The Price of Labour vs. the Cost of Labour

An important element in our studies on productivity and costs[22] was the question of the true cost of labour. Labour costs can be divided into two components: direct and indirect. Direct wages or compensation are defined as pretax wages that accrue to the worker as a result of hours actually worked.[23] Indirect compensation covers pay for time not worked; for example, vacations, holidays and sick leave; payments required by law, such as workers' compensation, unemployment insurance, etc.; benefit plans which include private pension plans, group insurance, etc.; and bonus and profit-sharing payments.

Gross pay is the total organizational payroll. As such, it consists of straight-time pay which is composed of "wages and salaries for time worked and for time not worked if wages and salaries are normally paid while an employee is on vacation, taking holidays, sick leave, etc. (pay for time not worked)".[24] Also included are premium payments (payments in excess of straight-time pay, for overtime shifts, holidays, etc.); incentive and production bonuses (but not organization bonuses such as profit-sharing plans), and finally other direct wage and salary payments such as isolation pay.[25]

[22] MPBP 19 and 25.

[23] Ostry, S. and M. Zaidi, *Labour Economics in Canada*, 3rd ed., Macmillan, 1979, p. 198.

[24] *Employee Benefit Costs in Canada*, 1984, Thorne, Stevenson and Kellogg, Management Consultants, p. 8.

[25] *Ibid.*

Like direct wages, indirect compensation, as defined, is simply another "cost" of carrying on a business in the 20th century, another way of paying money directly to employees and making them solely responsible for their own welfare. For reasons beyond the scope of this paper, we, as a society, have decided to do a number of these things collectively, either through employer contributions (e.g. to a pension fund), or via government auspices, such as workers' compensation or universal health schemes. This having been said, these indirect costs do impose a burden on employers and, one suspects, may reduce flexibility in manpower policy.

In order to get some perspective on the size of indirect labour costs, we calculated the ratio of indirect compensation to gross payroll. Between 1961 and 1977[26] this ratio increased from 16.3 percent to 43.9 percent, an increase of almost 170 percent. The comparable ratios for secondary manufacturing were 23.4 percent (1961) and 32.1 percent (1977), for an increase of only 37 percent. Although the mining industry had started behind general manufacturing in terms of indirect compensation, it caught up and surpassed it in less than two decades. The situation then reversed, and the ratio for mining declined; by 1984 it was the same for mining and general manufacturing: 33 percent.

What explanations can be offered for these rapid changes in the ratio of indirect labour compensation to gross payroll? Among the reasons why an employer would favour indirect over direct payments are

- the need to schedule work to avoid production interruptions; hence, the benefit of clearly defined vacation times;

- the perception that employee benefit plans, pensions, dental plans, etc., are valuable partly for the benefits themselves and partly for the resulting tax savings to the employees. They may also be seen as a lock-in device by the employer. Both of these factors have a positive effect on productivity. The lock-in effect adds a further incentive for the employer to support larger benefit payouts from a given increase in base pay.

Hence, there is a presumption that "locking in" employees leads to increased efficiency, a hint of the Japanese model of employee attachment. The fact that, for mining, indirect wages stopped growing relative to gross payroll in the 1980s suggests that, at the margin, the benefits and costs to employees as well as employers has about reached equilibrium. Employees are prepared to accept growth in indirect wage settlements that is equal to or even less than the growth in gross payroll. The discount rate has apparently risen; i.e. the perceived value of future dollars has fallen, relative to current dollars.

Table 17 provides a breakdown of the various components of indirect compensation and expresses these individual items in terms of a dollar of gross payroll. It also compares the metal mining sector to general manufacturing. The following points arise from these calculations.

- Taking the period as a whole, the ratios for all components are virtually trendless, i.e. there was no strong pressure to enhance one type of benefit over another.

- Within the period, benefit plans peaked in 1982, leading to a peak in the total indirect share.

- "Paid-Time-Off" includes the most "expensive" indirect benefits, i.e. holidays are costly in cash outlay and, of course, in disrupted production.

- Apparently, the slightly higher level of cost per dollar of indirect wages in mining vs. manufacturing comes both in negotiated benefit plans and in government-mandated schemes. Hence, whatever additional burden is carried by the mining sector originates both at the bargaining table and in government offices.

What effect do the differences in indirect benefits in mining have on take-home pay in this sector, compared to secondary manufacturing? The answer is, very little. Average compensation per employee in total metal mining for 1984 was $27,846, while in manufacturing it was $26,910. We might anticipate a slightly higher average wage in mining due to the potential hazards involved, as well as for underground work for some of the employees, although this is not clear. If there is some compensating difference, then it appears to be running in the right direction, i.e., towards slightly

[26] MPBP 25, p. 85ff.

Table 17

Indirect Labour Costs as Percentage of Gross Payroll, Ontario Metal Mining and Canadian Manufacturing, 1979-85

Year	Paid Time Off (1)	Other (2)	Required by Law (3)	Benefit Plans (4)	Total Indirect (5)
			(A) Ontario Metal Mining		
1979	8.0	1.0	10.9	9.5	29.4
1980	11.0	1.0	7.5	15.6	35.1
1981	11.1	1.0	7.8	14.2	34.1
1982	12.8	1.3	8.3	22.6	45.0
1983	11.2	1.6	8.5	14.3	35.5
1984	10.4	1.2	9.7	12.0	33.3
1985	10.5	1.6	10.0	11.9	33.9
			(B) Canadian Manufacturing		
1979	n.a.	n.a.	n.a.	n.a.	n.a.
1980	12.9	2.9	3.8	10.5	31.5
1981	n.a.	n.a.	n.a.	n.a.	n.a.
1982	13.3	3.2	4.1	9.7	31.8
1983	n.a.	n.a.	n.a.	n.a.	n.a.
1984	14.8	3.8	4.6	9.4	33.8
1985	n.a.	n.a.	n.a.	n.a.	n.a.

Sources: Panel A: Appendix Table 5, MPBP 25; Panel B: Thorne, Stevenson and Kellogg, *Employee Benefit Costs in Canada*, 1980, 1982 and 1984.

higher average take-home pay and related indirect compensation for those working in metal mining.

Distribution of Indirect Labour Costs Required by Law

There has been some discussion about the extra burden the mining sector bears in its payments for workers' compensation. Table 18 sets out the cost of each benefit mandated by government (i.e. required by law), per dollar of covered payroll. We focus on the workers' compensation ratio.

First let us define how firms are assessed for payments under this scheme. According to Ostry and Zaidi,

> workmen's compensation represents payments for private insurance. The ratios are, of course, determined by the incidence of accidents for the firm and by the type of work performed. In 1975-76, for example, the average cost per employee was $92 for the petroleum and pipeline industry and $290 for primary metals and metal fabrication. In comparison, the cost for the finance and insurance industry was only $5.[27]

As one might expect in any insurance scheme, premiums are adjusted to the level or risk. A differential is seen clearly in Table 18, where workers' compensation per dollar of gross payroll averages 1.5 percent for manufacturing and 5.0 percent for mining. In absolute dollar terms this translates to about $1,500 per employee in mining compared to about $275 per employee in manufacturing.[28] Two questions arise:

- Is the mining risk now five times that in manufacturing?

[27] Ostry and Zaidi, *Labour Economics in Canada*, pp. 214-218.

[28] See MPBP 25, Table VI-9.

Table 18

Government-Mandated Costs as Percentage of Gross Payroll, Ontario Metal Mining and Canadian Manufacturing, 1979-85

Year	Workers' Compensation	Unemployment Insurance	Canada Pension Plan	Silicosis Assessment	Total
			(A) Ontario Metal Mining		
1979	6.4	0.8	0.9	1.1	9.4
1980	6.4	1.1	1.1	0.8	9.4
1981	5.4	1.3	1.0	0.6	8.3
1982	5.2	1.0	1.0	0.6	7.8
1983	4.9	1.7	1.1	0.7	8.3
1984	5.6	1.9	1.0	0.8	9.3
1985	5.7	1.6	1.0	0.8	9.1
			(B) Canadian Manufacturing		
1979	n.a.	n.a.	n.a.	n.a.	n.a.
1980	1.33	1.27	1.15	n.a.	3.75
1981	n.a.	n.a.	n.a.	n.a.	n.a.
1982	1.2	1.6	1.3	n.a.	4.1
1983	n.a.	n.a.	n.a.	n.a.	n.a.
1984	1.3	2.1	1.2	n.a.	4.6
1985	n.a.	n.a.	n.a.	n.a.	n.a.

Sources: Panel A: Ontario Metal Mining: Labour Cost Survey of Ontario Metal Mines - Update, MPBP 25; Panel B: Thorne, Stevenson and Kellogg, *Employee Benefit Costs in Canada*, 1980, 1982 and 1984.

- Has the difference in risk remained constant? The ratio shows little change between 1979 and 1985, although the absolute amount of payment grows at about the same rate as gross payroll.

Benefit Plans

Table 19 sets out private benefit plans offered by employers, and shows that the cost of benefit plans per dollar of gross payroll is higher in mining than in manufacturing. In our earlier study, we found that the ratios are higher for mining firms.[29] However, we will need much more detailed or firm-level data before we can explain why such differences are observed.

Finally, we should ask: How important is it to include indirect payments in calculating labour productivity and TPF? In our earlier study,[30] we found indirect labour expenses were a significant component of the wage equation. When the full cost of labour is included (i.e. direct plus indirect costs), the ratio of the combined total to direct wages alone is approximately 1.4 to 1.0. If we adjust the wage share for this difference it raises it by 44 percent. Since the factor shares must add to 1.0, this means a reduction in the share of capital. The latter is obtained as a residual.

[29] Ibid.

[30] See discussion on pp. 112-115 in MPBP 25.

Table 19

Benefit Plans as a Percent of Gross Payroll, Ontario Metal Mining and Canadian Manufacturing, 1979-85

(A) Ontario Metal Mining

Year	Private Pension Plans	Provincial Medical Plans	Life and Health Insurance	Total
1979	3.85	1.87	2.61	9.49
1980	10.16	2.78	2.24	15.63
1981	8.96	2.64	2.15	14.18
1982	7.48	3.71	3.03	14.67
1983	7.98	3.48	2.38	14.26
1984	5.84	2.94	2.62	12.02
1985	6.06	1.85	2.70	11.88

(B) Canadian Manufacturing

Year	Pension Plans	Welfare Plans	Total
1979	n.a.	n.a.	n.a.
1980	4.74	5.72	10.46
1981	n.a.	n.a.	n.a.
1982	4.8	4.9	9.7
1983	n.a.	n.a.	n.a.
1984	4.0	5.4	9.4
1985	n.a.	n.a.	n.a.

Source: Panel A: Sample Survey of Ontario Metal Mines - Update, MPBP 25; Panel B: Thorne, Stevenson and Kellogg, *Employee Benefit Costs in Canada.*

This change in share weights can affect the TFP index. If labour productivity is increasing, then a higher weight or share for labour will mean that total factor productivity, as a residual, will be falling, and the impact of technical change will be less than that shown previously. The productivity results credited to technical efficiency, then, are probably biased upwards, and the rates of return are probably biased upwards as well.

We must again ask what factors drove the high levels of real investment in the 1980s, if in fact technical efficiency and rates of return are lower as a result of rising total labour costs (direct plus indirect) in the industry. One possible explanation is that producers sought to offset these higher labour costs by substituting capital for labour, as economic theory would suggest.

Canadian vs. US Wage Costs

Our earlier study[31] included a Canada-United States wage comparison. Here we present only the highlights of this comparison.

- Over the period 1980-86 the annual wage increase for Canada was 7.5 percent while for the U.S. it was 5.6 percent. By 1986, wage costs in Canada exceeded those in the U.S.

- Beginning with the depression of 1982 and extending to 1984, the rate of wage increase in Canada and the U.S. was about the same. This indicates a greater adjustment to falling demand in Canada for Canadian vs. US workers.

[31] MPBP 25, p. 121ff.

- In the US mining sectors, employees in some copper and coal companies actually agreed to wage reductions in the face of declining commodity prices. This example was not followed in Canada. Apparently, Canadian mineworkers chose to live with higher levels of unemployment than their US counterparts. This might be related to the more generous unemployment benefits in Canada than exist in the U.S.

- A crude comparison of average hourly wages suggests that Canadian levels exceed their US counterparts.

- The ratio of indirect compensation per dollar of gross payroll is roughly about the same in both countries, i.e. about 30 percent.

The overall conclusion is that, all other factors being equal, if Canadian producers are going to compete with their US counterparts, either they need to be more efficient, to offset the higher price of inputs, notably labour, or they require a depreciated Canadian dollar. The concern of mining companies every time the Canadian dollar moves closer towards parity with the US dollar can now be better understood.

Efficiency gains have not as yet offset higher average labour costs. Furthermore, evidence on trends in real costs presented at the beginning of the chapter leads one to believe that the efficiency route is not all that certain. This might also help to explain why Canadian producers embarked on such a vigorous capital-deepening campaign. Again we will need more detailed data to see whether, in fact, this is the case.

7. Summary and Conclusions

All industries in the Western trading nations, and in the Third World as well, had to adjust to a post-OPEC crisis world of rising prices, higher unemployment and slower productivity growth. Our concern in this work has been with productivity, and especially with the response of the metal mining industry in Ontario to these external imperatives. Mining is a particular case. It suffers more acutely than the economy as a whole when economic conditions deteriorate and rebounds more vigorously when conditions improve. Managing the allocation of resources in such a volatile set of conditions requires a deep understanding of the forces driving this sector.

The basic cyclical influences that affect this industry so strongly are clearly written in the various data series covering the years since 1961. The decade of the 1960s was a period of expanding demand with real output growing at an annual rate of 3.6 percent. Thereafter, conditions deteriorated sharply and for the next 15 years demand declined. Real output, measured in tons of ore hoisted, fell from 65.5 thousand in 1960 to 44.9 in 1984, or at an annual rate of 2.9 percent. The industry had to respond to a new and very different set of conditions.

Our work here addresses the question: How did the metal mining industry respond to a prolonged period of declining demand? The productivity trends in mining were not quite as good as those in general secondary industry. Nevertheless, within the context of the worldwide conditions and its greater volatility, the mining industry responded well - as we believe our empirical results revealed in our various indices of efficiency.

Let us review again the evidence of the industry's performance. We examined the industry's response by examining, systematically, how various inputs - capital, labour, materials and energy were adjusted in the face of declining demand. The systematic aspect took its shape from a very simple production function (Cobb-Douglas), within which we not only analyzed levels and trends in average productivity of each factor input, but then combined these inputs and estimated trends in technical efficiency. The latter measure is referred to as total factor productivity (TFP). We followed on in this study from our previous inquiry that ended at 1977.

Let us briefly summarize the key findings as outlined in the earlier chapters.

- Labour productivity (i.e. real output per worker) is often treated as the key index of industry performance. Our findings support this view. We found it tracked the more complex estimates of TFP quite closely over the period 1975-84. Both indices rose (performance improved) slightly from 1975 to 1978 and then both fell steadily to 1982, although the labour productivity index fell faster. Labour productivity and TFP (technical efficiency) both rose after 1982, with the labour index rising faster. The sharper decline for labour productivity reflected the slow decline in labour input (slower than the decline in output) until the early 1980s when the employment levels were cut quite sharply.

- We partitioned labour into blue and white collar workers, since the two are distinct inputs and are treated quite differently by employers. Economic theory suggests, for example, that white collar workers are more like capital, i.e. they represent a longer-term investment. Hence the employer is more reluctant to lay them off when economic conditions deteriorate since they are costly to replace.

  The important finding was that employment of white collar workers accelerated sharply between 1961 and 1981, increasing from under 5,500 to 7,500. On the other hand, the number of blue collar workers declined over this period, from 31,500 to 28,000. Labour input had, therefore, gone through a major structural change.

  White collar workers, we suggested, should be considered as quasi-fixed capital. Furthermore, it was seen as complementary to physical capital, i.e. the two grew or shrank together. This was certainly the case for over two decades. However, beginning in 1981 this situation was reversed: the stock of physical capital continued to grow but the number of white collar workers

started to decline. By 1984 there were 2,000 fewer such workers employed.

We usually define white collar workers as administrators, engineers, sales personnel, office staff, etc. These groups generally consider their employment as more stable than that of blue collar workers. Hence, the sharp cut-back in white collar workers in the early 1980s was a distinct break from the recent experience of these workers. One must wonder whether any consequences followed, especially as expansion returned to the industry in the late 1980s and it became necessary to refill positions left vacant by layoffs.

- Capital productivity followed a similar trend until the early 1980s, when output per unit of capital input fell sharply. This change was due to massive investments by the industry that got underway in the late 1970s and increased sharply in the early 1980s. Without the expected cyclical recovery in demand in the early 1980s, the productivity of this capital fell.

- On the remaining two factors, materials and energy, we have less to say. This does not mean we consider them unimportant - quite the contrary. Material costs represent over 30 percent of the value of total sales. Energy's cost is much less, at about 4 percent of sales. However, our detailed evidence on these two inputs is less. For energy, we did notice that its growth, after the 1974 rise in energy prices slowed substantially, suggesting that the industry did practice conservation in usage. The amount of capital/energy substitution was probably small, given the slow adjustment of technology to these changing relative prices.

- Finally, we continued our investigation of the growing gap between the price of labour (direct wages) and the cost of labour (direct plus indirect wages). Indirect labour costs include all fringes, negotiated and mandated. The main change here was the slowdown in the growth of indirect costs. By the mid-1980s the share of indirect labour costs in the mining industry was about the same as that in secondary manufacturing. A change in the trade-off between current take-home pay and future benefits (e.g. pensions, insurance, etc.) entered into negotiations. However, by the mid-1980s, indirect benefits (the cost of labour) were still substantially higher than in the early 1960s, and this reduced the degree of flexibility in manpower management.

- Technical efficiency trends were disappointing, especially during the eighties. Recall, however, that this measure of efficiency is a residual and so carries with it all the measurement and analysis problems of all the measured variables. The decline in efficiency for the 1980s was due, in the main, to the large investments undertaken by the industry during this period. Although this sounds contradictory, it is not. The large increase in real capital stock brought with it the latest techniques in efficient mining. However, in order for this total vision of the future to pay off, it had to be matched by a rebound in demand. Unfortunately, the markets for metals did not begin to turn around significantly until after the end of our study period. Current success is indeed based on these past investment decisions.

Apparently, the basic strategy of the metal mining industry was to meet rising costs and Third-World competition by widespread adoption of best-practice technology; to meet the competition's subsidized production with sophisticated capital-intensive techniques. In order to understand how this approach actually worked in the industry, the next logical step would be to investigate firm-level response to external events.

Appendix A

Production Function

We have used the standard Cobb-Douglas production function as our basic underlying model. The non-stochastic form is as follows:

$$Q_{i,t} = A\ L_{i,t}^{\alpha}\ K_{i,t}^{\beta}\ M_{i,t}^{\gamma}\ E_{i,t}^{\lambda}$$

or in log form:

$$g_{i,t} = a + \alpha \ell_{i,t} + \beta k_{i,t} + \gamma m_{i,t} + \lambda e_{i,t}$$

where g = real output; ℓ = number of employees; k = real capital stock; m = materials and e = energy; α, β, γ, λ are the parameters or, as measured in our work, factor shares. The subscript i refers to the particular firm and t to the year. The underlying assumption is one of constant returns to scale, i.e. $\alpha + \beta + \gamma + \lambda = 1$

Unfortunately, we do not have enough observations to test econometrically whether the industry is subject to increasing or decreasing returns. The regression equation that would be estimated is

$$(g_{i,t}-\ell_{i,t}) = a + \beta\,(k_{i,t} - \ell_{i,t}) + \gamma\,(m_{i,t}-\ell_{i,t}) + \lambda\,(e_{i,t}-\ell_{i,t}) + \mu_{i,t}$$

where the variables are as defined above except that we have added an error or perturbation term, e_{it}.

In the work reported on in Chapter 6, we estimate our productivity levels and annual rates of growth as specified above.

Appendix B

Index of Output, Inputs and TFP, Metal Mining in Ontario
Annually, 1961-77 (1961 = 100)

Year	Total Factor Productivity $\hat{A}$[a] (1)	Real Output $\hat{Q}$ (2)	Real Capital Stock $\hat{K}$ (3)	Labour in Man Year $\hat{L}$ (4)	Real Materials Input $\hat{M}$ (5)	Energy Input in BTUs $\hat{E}$ (6)	Weighted Total of Inputs $\hat{I}$[b] (7)
1961	1.000	1.00	1.00	1.00	1.00	1.00	1.000
1962	.960	0.92	0.97	0.95	0.95	0.93	0.958
1963	0.931	0.85	0.93	0.88	0.91	0.93	0.913
1964	1.000	0.92	0.90	0.88	0.97	0.97	0.921
1965	1.080	1.05	0.87	0.89	1.14	1.05	0.972
1966	1.000	0.98	0.91	0.89	1.11	1.18	0.981
1967	0.980	1.13	0.97	0.89	1.50	1.59	1.153
1968	1.089	1.35	1.04	0.90	1.62	2.06	1.240
1969	0.964	1.16	1.05	0.78	1.56	2.16	1.203
1970	1.004	1.46	1.13	0.94	2.08	2.42	1.454
1971	0.945	1.42	1.19	0.95	2.12	2.64	1.502
1972	0.982	1.31	1.20	0.87	1.67	2.58	1.334
1973	1.035	1.35	1.15	0.86	1.65	2.54	1.304
1974	1.077	1.36	1.04	0.92	1.60	2.89	1.262
1975	1.011	1.26	1.01	0.91	1.61	2.79	1.246
1976	1.023	1.33	1.02	0.92	1.72	3.09	1.300
1977	1.016	1.30	1.03	0.93	1.66	2.82	1.279

Source: MPBP 19, p. 61 and p. 129.
[a] Total factor productivity is derived by dividing column (2) by column (7).
[b] The weights used are K = .4298, L = .2030, M = .3379 and E = .0279.

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